Space Weather Technical Forecast

Issued on Wednesday, 20 December 2023 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of isolated M-class flares throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity is Low, with the peak flare a C7.3 event at 19/0304 UTC from AR3528. Ten sunspot regions feature on the visible disc. AR3529 in the southeast is the largest of these, with continued growth in penumbral extent observed and some evidence of the development of small intermediate spots of mixed polarity resulting in a beta-gamma Mount Wilson classification. AR3526 and AR3528 are two notable spots in the northeast, with slight increase in areal extent observed and proliferation of intermediate spots. Newly numbered AR3530 in the far northeast contains several modest sized spots, but with a broadly open configuration. AR3519 in the southwest has developed beta-gamma magnetic complexity, but otherwise remains largely unchanged. All other spots are small and simple.

No Earth-directed CMEs have been observed in coronagraph imagery.

Solar Wind / Geomagnetic Activity: The solar wind environment was characterised the ongoing effects of a connection to the high-speed stream of coronal hole 82. Solar wind as measured by ACE at L1 was at mainly strong levels, largely around 600km/s but with a peak of 719km/s at 19/0643 UTC, but has recently declined to around 570-600km/s. Density was predominantly below average. The IMF was initially moderate with a peak of 9nT at 19/0000 UTC, before becoming weak from 19/0059 UTC. The north-south component of the IMF varied from +7/-7nT and was largely positive in direction, though was mainly negative between 19/0000-0400 UTC. The phi angle was mostly positive (away from the Sun), but became mainly negative (towards the Sun) between 19/1400-19/2000 UTC. Resultant geomagnetic activity was largely Quiet to Unsettled (Kp 1-3), but with an Active (Kp4) interval from 19/0000-0300 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels.

GOES16 high energy (greater than 2MeV) electron flux was mostly at normal background levels with a brief diurnal peak at moderate (208pfu at 19/19/1855 UTC). The 24-hour fluence was well below the Active threshold (1e8 integrated pfu) on a steady trend. The observation at 20/0000 UTC was 1.46e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low with a chance of becoming Moderate with isolated M-class flares. The greatest risk of significant flares is currently from AR3526, AR3528 and AR3529.

Solar Wind / Geomagnetic Activity: A weak CME arrival is possible early on day 1 (20 Dec), otherwise no Earth-directed CMEs feature in the forecast period. Solar winds are currently at elevated to strong levels due to the ongoing high speed stream of coronal hole 82. Speeds should slowly ease back to persistently elevated, then later slightly elevated through days 1 and 2 (20-21 Dec). On day 2 or 3 (21-22 Dec) there is the chance of a connection to coronal hole 83 in the southern hemisphere that could result in a further enhancement to the solar wind, however confidence for this is low given its mid-latitude location on the disc. In the absence of any further

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enhancement in later days, winds should trend back towards background speeds.

Geomagnetic activity should remain largely Quiet to Unsettled during the period. There is a chance of peak Active conditions and a slight chance of a G1/Minor storm interval upon the arrival of a weak CME early day (20 Dec), or from the possible onset of the high speed stream of coronal hole 83 on days 2 or 3 (21/22 Dec).

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is at Background levels and expected to remain at similar levels unless any significant flaring occurs.

High energy electron flux is predominantly at normal background levels and is expected to remain similar early in the period, due to the ongoing, but declining fast wind from coronal hole 82 and a potential CME influence. Daily High electron levels may be achieved from day 2 (20 Dec) onwards and may reach more persistently High levels on subsequent days, although depends strongly on the potential arrival of the high-speed stream from coronal hole 83 that could suppress electron counts again. Thus, Active electron fluence is considered very unlikely throughout, but with confidence becoming low from day 3 (22 Dec) onwards.

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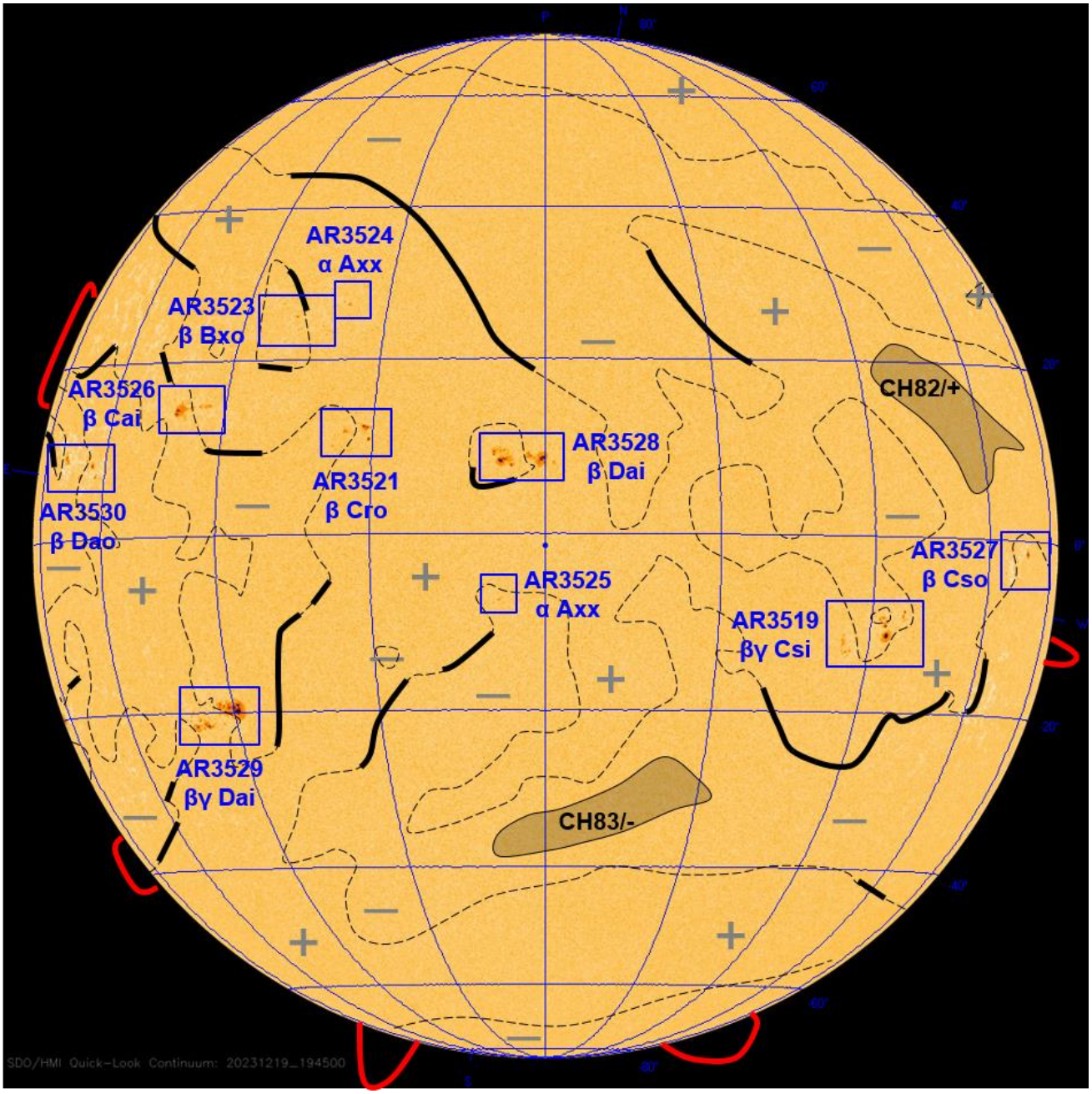
Figure 1. Solar Analysis Valid 19/1945 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

There is one potentially Earth-directed CME in the forecast, resulting from the 15/2100 UTC south-centre disc filament eruption. The window of any potential arrival at Earth extends up to the middle of day 1 (20 Dec), although there is a chance that no impact will be observed given only a weak signal in coronagraph imagery as the CME left the sun and subsequent low confidence analysis of the feature. Any effects at Earth are expected to be minor if they do occur.

Enhanced solar winds from CH82/+ are currently at elevated to strong levels (between 570-600km/s). Speeds should slowly ease back to persistently elevated, then later slightly elevated through days 1 and 2 (20-21 Dec).

The next potential HSS enhancement is from CH83/-. This is a recurrent feature, however, no apparent connection was made to Earth on the previous rotation. Conversely, this feature appears larger and darker than previous rotation therefore may yet become geo-effective in the coming days, with the earliest reasonable arrival time from the middle of the UTC day on day 2 (21 Dec) and latest potential onset during the second half of day 3 (22 Dec). The corresponding period on the previous rotation in late November was heavily influenced by the arrival of multiple CMEs and this may have masked any connection to the coronal hole at the time. Consequently, confidence in the timing and extent of any connection to this feature is low. If it were to become geo-effective, speeds could peak between slightly elevated and strong levels. Given the coronal hole's southerly location (mainly between 30S-40S) on the disc and proximity to the solstice, any geomagnetic effects should be small with limited enhancements.

In the absence of any further coronal hole enhancement in later days, winds should trend back towards background levels.

Geomagnetic activity should remain largely Quiet to Unsettled during the period. There is a chance of peak Active conditions and a slight chance of a G1/Minor storm interval upon the arrival of a weak CME early day (20 Dec), or from the possible onset of high speed stream of CH83/- days 2 or 3 (21/22 Dec).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	10	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/1947	Partial	Filament eruption	S Centre	341 km/s	Late 19 or early 20 Dec	Low confidence

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Radio Blackouts - X-Ray Flares:

Although current activity is Low, there remains a daily chance of isolated M-class flares.

Ten sunspot regions feature on the visible disc. AR3529 in the southeast is by far the largest, with ongoing growth in penumbral extent of the leader spot observed in recent hours. There are also a number of small spots of mixed polarity that occupy the intermediate portion of the group. Further development of these could act to destabilise the region further. AR3528 is another notable spot close to centre disc in the northern hemisphere, with slight increase in areal extent and proliferation of intermediate spots. Newly numbered AR3530 in the far northeast contains several modest sized spots, but with a broadly open configuration. AR3519 in the southwest has developed beta-gamma magnetic complexity, but otherwise remains largely unchanged. All other spots are small and simple. A new region appears to be rotating over the southeast limb at present, but is too foreshortened in available imagery to make an accurate assessment of its classification at this time.

Several new or returning sunspot regions are expected to appear over the eastern solar horizon in the period, however far-side soundings and limb EUV flux are not readily backed up by CME and dimming evidence to suggest any overly active regions.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

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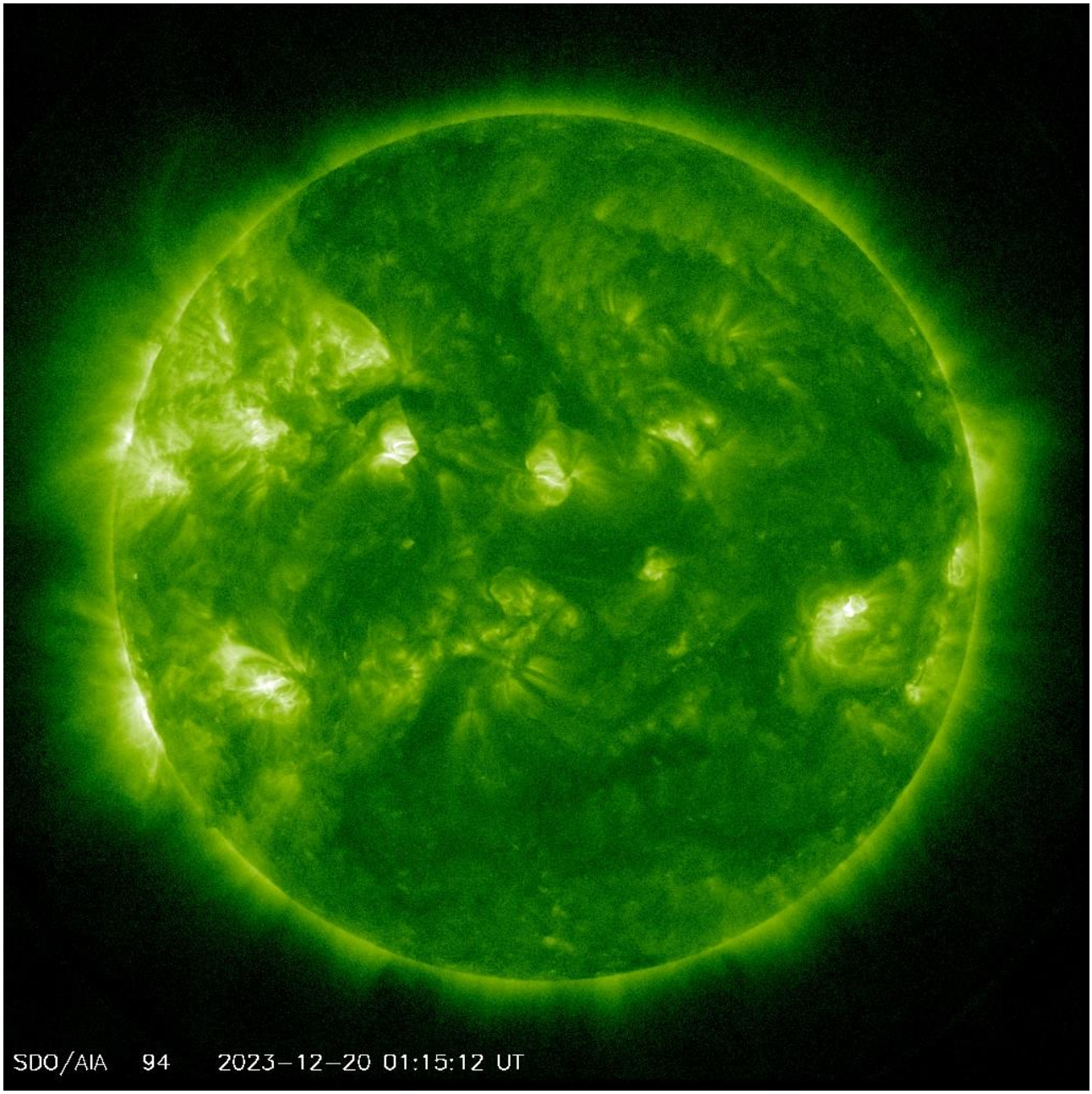
Figure 2: SDO/AIA 94 imagery at 20/0115 UTC



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is at normal background levels and expected to remain at similar levels unless any significant flaring occurs.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux is at largely normal background levels and expected to remain so early in the period due to the ongoing, but declining fast wind from CH82/+ and potential CME arrival early day 1 (20 Dec). Daily High electron flux levels may be achieved from day 2 (20 Dec) onwards as the solar wind pressure subsides and the Van Allen belts relax towards background again. This may continue through days 3 and 4 (22-23 Dec), with a chance of more persistently High levels, however, any connection to CH83/- (low confidence) would act to suppress electrons once again to become mainly background.

There is high confidence that electron fluence will remain below the Active (1e8 integrated pfu) threshold on days 1 and 2 (20-21 Dec). From day 3 (22 Dec) onwards Active fluence is not expected, but carries low confidence, with a slight chance of exceeding threshold values.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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Figure 3: GOES16 >2MeV Electron flux (above) and 24hr Fluence with REFM (below)

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